REMARKS

The claims under consideration in the case are 1, 4-28, 30, 31, 34, 36-49, and 69-70. Claims 50-68 remain withdrawn due to the Requirement for Restriction.

Support for the amendment to Claims 1, 23, 36, 38, and 70 is found in the Specification at least at Page 12, paragraph 00043, at Page 23, paragraph 00077, and in Example 1, paragraph 000125. The amendment to Claims 38 and 69 removes "a)", which is unnecessary in light of the absence of other labels. Support for new Claims 71-75 is found in the Specification at least at Page 21, paragraphs 00068-00069. No fees are believed to be due for these new claims, due to the number of claims that have been cancelled in the case.

The Examiner's responses to Applicants' arguments in the Final Office Action and in the Advisory Action are appreciated, and will be discussed below in the context of the §103 rejection, to which they pertain.

Rejection under §103 over U.S. 4,228,297

Claims 1, 4-28, 30, 30, 34 and 36-49, and 69-70 are rejected under 35 U.S.C. §103(a) as obvious over Haeberli et al. (US 4,228,297) in view of Grant et al. (*Chemical Dictionary*, 1990, p. 11-12). Applicants respectfully request reconsideration and withdrawal of this rejection.

As to the teachings of Haeberli et al. regarding the catalyst, Applicants' point was that Haeberli et al. overwhelmingly teaches that two different catalysts should be used, even though Haeberli et al. states that "The second alkaline catalyst may be selected from the classes of compounds listed above for the first alkaline catalyst" (column 9, lines 1-3).

There is no suggestion in the cited references, either alone or in combination, of using aqueous phosphoric acid in place of acetic acid, much less for effecting a clean separation of the salts formed by the neutralization from the reaction product mixture. The cited references do not hint at the benefits of using phosphoric acid in the claimed esterification process.

Haeberli et al. is fundamentally different than the presently claimed invention in ways which preclude the obviousness of the present claims.

As noted on Page 5 of the Office Action of April 16, 2009, a difference between Haeberli et al. and the present claims is the use of acetic acid in Haeberli et al. while the present case uses aqueous phosphoric acid to neutralize the catalyst. The Office Action further states that both phosphoric acid and acetic acid are well-known, citing Grant et al., and concludes that because acetic acid and phosphoric acid are both well-known, it is obvious to use one in place of the other. However, this overlooks the chemical differences of these two acids. Phosphoric acid is a strong acid, while acetic acid is a weak organic acid. In this connection, see Lewis, Jr., *Hawley's Condensed Chemical Dictionary*, 13th ed., 1997, pages 14-15, attached to this Response as Exhibit A. Since acetic acid and phosphoric acid are quite different chemically, there is no motivation to use phosphoric as an alternative to acetic acid.

Another difference between the presently claimed invention and Haeberli et al. is the nature of the products formed in each. The esterification products of the present claims are liquids at or close to room temperature (*e.g.*, less than about 50°C), while those of Haeberli et al. are solids. In Haeberli et al., the product of Example 1 has a melting point of 71.5°C; the product of Example 2 has a melting point of 105°C; the Example 3 product has a melting point of 50°C; and the Example 4 product has a melting point of 110-125°C. Thus the present claims and Haeberli et al. are directed to esterification products that have different properties.

To be clear regarding the neutralization step, in the presently claimed processes, aqueous phosphoric acid is added to the reaction mixture, which is stirred to ensure contact, and then water is removed from the mixture. Upon removal of water, a precipitate forms, which precipitate is the salt(s) formed in the neutralization reaction; the esterification product is a liquid. In contrast, in Haeberli et al., the catalyst is neutralized with acetic acid, and the esterification product is crystallized (precipitated) from a suitable solvent (column 9, lines 29-34). See in this connection Example 1 of Haeberli et al., where it is stated

> [T]he vacuum was then released with nitrogen, and the reaction mass was cooled to 70°C and acidified with 3.0 g of glacial acetic acid. <u>132 g of ethyl alcohol</u> were <u>added</u> to the melt, and the resultant solution was clarified. The filtrate was cooled

to 28°C and seeded with 0.5 g of thio-bis-{ethylene-3-(3,5-di-t-butyl-4-hydroxyphenyl)propionate}. The reaction product crystallized. (Column 10, lines 47-55, emphases added.)

In the Office Action of April 16, 2008, at the top of Page 6, the above passage is quoted, and it is incorrectly inferred therein that the salts formed by the neutralization precipitated. In this connection, alkali metal acetates are known to be soluble in alcohol; see the relevant entries for lithium acetate, potassium acetate, and sodium acetate from the *CRC Handbook*, 63rd ed., Pages B-113, B-130, and B-145, attached to this Response as Exhibit B. Thus, the filtration in Haeberli et al. must have removed some other solid impurity.

Furthermore, several benefits are obtained in the present case, at least some of which are a result of using aqueous phosphoric acid:

• A precipitate is formed without need for addition of solvent or other reagents.

• The precipitated salts are easily removed from the liquid esterification product.

• Because a solvent addition is not needed to effect precipitation, the process can be conducted in smaller reactors. The presently claimed process employs a very small amount of water (which is nonhazardous). Haeberli et al. uses a large excess of ethyl alcohol, from which the esterification product is crystallized. More particularly, in Example 1 of Haeberli et al., the amount of ethanol (132 g) is 42.2% of the total weight of reagents used in the process therein. In the present case, Example 1 utilizes 34.7 g of water, which is only 4.4% of the total weight of reagents used in the process. Thus, the present invention provides a substantial reduction of solvent use and of cost. Further, the reduction in solvent usage in turn allows the manufacture of more product in a particular reactor; in other words, more product can be produced per unit volume of reaction mass.

• Nearly complete removal of the catalyst metal from the esterification product has been achieved as shown in Example 3 (Page 42, paragraphs 000138-000139), where only 2.3 ppm potassium remained in the esterification product, a removal of more than 99.9% of the potassium.

• High yields of the esterification product are obtained. Applicants' Example 6 (Pages 46-47, paragraphs 000158-000165) shows a 97.4% isolated yield, based on 2,6-di-tert-butyl-phenol (the limiting reagent in Example 6). In this context, the highest isolated yield in

Haeberli et al. is 87% (Example 3), though Applicants maintain their position that Haeberli et al. is not directly comparable to the presently claimed invention.

• There is a significant reduction in the amount of waste solids produced, greater than 60% in comparison to prior processes. The claimed process typically generates waste solids on the order of between about 0.65% and 1.02% by weight, based on the phenolic ester product; by comparison, other reported methods generate as much as 2.70% solids (Specification, Page 12, paragraph 00045).

The Examiner has repeatedly asked for unexpected results. At least some, if not all, of the above benefits of the presently claimed invention constitute unexpected results. Similarly, the Examiner has also reiterated a suggestion to make a side-by-side comparison of the presently claimed invention to the process disclosed in Haeberli et al. To the extent possible, the relevant portions of Haeberli et al. were discussed with (compared to) each of the above beneficial features of the present invention.

While a true side-by-side comparison is not really feasible since the Haeberli et al. esterification product is a solid and the claimed process' esterification product is a liquid, in the spirit of a more complete side-by-side comparison, Example 7 of the present case is highlighted. In Example 7, a product mixture made (to that point) in accordance with the present invention was combined with acetic acid (rather than phosphoric acid) to neutralize the catalyst, as follows:

combined reaction mixture with acetic acid (1.55 g; mixture became yellow and cloudy);
water was added (10.3 g);
water was stripped (mixture became hazy);
more acetic acid was added (1.55 g);
mixture was washed twice with water (182 g, 177 g; water washes were discarded); and
organic layer was stripped at 20 mmHg and 120°C.

Some observations regarding this neutralization in Example 7 can be made. First, as mentioned in previous Responses, no precipitate was formed; thus acetic acid does not function in quite the same way in the processes of the present invention that aqueous phosphoric acid does. The initial amount of acetic acid, 0.375 mole, is enough to neutralize the catalyst (0.037 mole). Upon addition of more acetic acid, a total of 0.63 mol, a 70% excess, had been used. Thus a large excess of acetic acid is not enough to cause precipitation of the salts formed by the neutralization reaction. The isolated yield in Example 7 based on 2,6-di-tert-butyl-phenol is 100.3%,

suggesting that the separation of the salts from the esterification product is not clean; an impurity is present.

A feature of the process in Haeberli et al. which has no equivalent in the processes of the present invention is the organic liquid waste produced by the neutralization/workup step. Haeberli et al. uses a large excess of ethyl alcohol in order to separate the salts of neutralization from the esterification product, and to isolate the esterification product as a solid. This results in the formation of organic waste composed of the recovered ethyl alcohol, which contains the salts from neutralized catalyst and lost product that did not crystallize out of the ethyl alcohol. The large amount of waste is both costly and an environmental issue. Specifically, it is again noted that in Example 1 of Haeberli et al., the amount of ethanol (132 g) is 42.2% of the total weight of reagents used in the process therein.

In the Advisory Action at Page 4, second paragraph, it is stated that "the only role of acid is to neutralize the base in the process." The primary role of the acid is to neutralize the base (catalyst). It should be clear from the discussion throughout this Response that the salts formed in the neutralization reaction are desirably separated from the esterification product, and thus, a secondary consideration is the fate of the salt(s), that it would not have been obvious to use phosphoric acid instead of acetic acid based on the combination of the cited references, and that substituting a phosphoric acid for acetic acid is not merely a matter of routine experimentation. Moreover, there was no expectation that such a modification would have been "feasible and successful as shown in the prior art" (Advisory Action, Page 4, second paragraph, penultimate line), because of such modification was **not** shown or suggested in the prior art, much less shown to be successful, and thus there would have been no expectation of success.

None of the advantages of using aqueous phosphoric acid shown in the present case are taught or suggested by the cited references. Nothing in Haeberli et al. suggests that there are any ill effects to the use of acetic acid or need for improvement in the process taught therein.

We turn now to new Claims 71-75, which are direct to a one-step esterification process. Applicants' Example 5 illustrates a one-step process of the present invention, in which the

product had a purity of 94.84% by GC analysis. Haeberli et al. does not teach or suggest a one-step process for obtaining esterification products.

In light of the foregoing amendments and remarks, the case is believed to be in condition for allowance. Prompt notification to this effect would be sincerely appreciated.

If any matters remain that require further consideration, the Examiner is requested to telephone the undersigned at the number given below so that such matters may be discussed, and if possible, promptly resolved.

Please continue to address all correspondence in this Application to Albemarle Corporation at the address of record.

Respectfully Submitted,

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Hawley's

Condensed Chemical

Dictionary

THIRTEENTH EDITION

Revised by

Richard J. Lewis, Sr.

JOHN WILEY & SONS, INC.
New York • Chichester • Weinheim • Brisbane • Singapore • Toronto

EXHIBIT A

Grade: Technical.
Use: Dyes.

acetyl triallyl citrate.
$CH_3COOC_3H_4(COOCH_2CH:CH_2)_3$.
Properties: Liquid. Boiling range 142–143C (0.2 mm), d 1.140 (20C), refr index 1.4665 (25C), flash p 365F (185C). Combustible.
Use: Cross-linking agent for polyesters; monomer for polymerization.
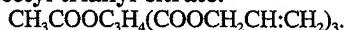
acetyl tributyl citrate.
$CH_3COOC_3H_4(COOC_4H_9)_3$.
Properties: Colorless, odorless liquid. Distillation range 172–174C (1 mm), pour p −60C, d 1.046 (25C), bulk d 8.74 lb/gal (25C), refr index 1.4408 (25C), viscosity 42.7 cP (25C), flash p 400F (204C). Insoluble in water. Combustible.
Derivation: Esterification and acetylation of citric acid.
Grade: Technical.
Use: Plasticizer for vinyl resins.
See "Citroflex A-4" *[Morflex]*.

acetyl triethyl citrate.
$CH_3COOC_3H_4(COOC_2H_5)_3$.
Properties: Colorless liquid; odorless. Distillation range 131–132C (1 mm), pour p −47C, d 1.135 (25C), bulk d 9.47 lb/gal (25C), refr index 1.4386 (25C), viscosity 53.7 cP (25C), flash p 370F (187C). Slightly soluble in water. Combustible.
Derivation: Esterification and acetylation of citric acid.
Grade: Technical.
Use: Plasticizer for cellulosics, particularly ethyl cellulose.
See "Citroflex A-2" *[Morflex]*; "ATEC." *[Morflex]*.

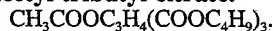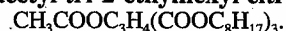**acetyl tri-2-ethylhexyl citrate.**
$CH_3COOC_3H_4(COOC_8H_{17})_3$.
Properties: Liquid. Bp 225C (1 mm), flash p 430F (222C). Insoluble in water. Combustible.
Grade: Technical.
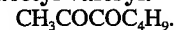**Use:** Low-volatility plasticizer for vinyl resins.

acetyltri-*n*-hexyl citrate. See "Citroflex A-6" *[Morflex]*.

N-acetyltryptophan.
Available commercially as *N*-acetyl-*l*-tryptophan, mp 185–186C; *N*-acetyl-*dl*-triptophan, mp 205C.
Use: Nutrition and biochemical research; medicine.

acetyl valeryl. (heptadione-2,3).
$CH_3COCOC_4H_9$.
Properties: Yellow liquid. Combustible.
Grade: 92% pure.
Use: Cheese, butter, and miscellaneous flavors.

acetyl value. The number of milligrams of potassium hydroxide required for neutralization of acetic acid obtained by the saponification of 1 g of acetylated fat or oil sample. Acetylation is carried out by boiling the sample with an equal amount of acetic anhydride, washing, and drying. Saponification values on acetylated and on untreated fat are determined. From the results the acetyl value is calculated. It is a measure of the number of free hydroxyl groups in the fat or oil.

ACGIH. See American Conference of Governmental Industrial Hygienists.

"Achromycin" *[Cytec].* TM for tetracycline hydrochloride.

acicular. Used to describe needle-shaped crystals or the particles in powders.

acid. One of a large class of chemical substances whose water solutions have one or more of the following properties: sour taste, ability to make litmus dye turn red and to cause other indicator dyes to change to characteristic colors, ability to react with and dissolve certain metals to form salts, and ability to react with bases or alkalies to form salts. All acids contain hydrogen. In water, ionization or splitting of the molecule occurs so that some or most of this hydrogen forms H_3O^+ ions (hydronium ions), usually written more simply as H^+ (hydrogen ion).

Acids are referred to as strong or weak according to the concentration of H^+ ion that results from ionization. Hydrochloric, nitric, and sulfuric are strong or highly ionized acids; acetic acid (CH_3COOH) and carbonic acid (H_2CO_3) are weak acids. Tenth normal hydrochloric acid is 100 times as acid (pH = 1) as tenth normal acetic acid (pH = 3). The pH range of acids is from 6.9 to 1. See pH.

When dealing with chemical reactions in solvents other than water, it is sometimes convenient to define an acid as a substance that ionizes to give the positive ion of the solvent. The common definitions of acid have been extended as more detailed studies of chemical reactions have been made. The Lowry-Brønsted definition of an acid as a substance that can give up a proton is more useful in connection with an understanding of bases (see base). Perhaps the most significant contribution to the theory of acids was the electron-pair concept introduced by G. N. Lewis around 1915. See Lewis electron theory.

The terms *hard* and *soft* acids and bases refer to the ease with which the electron orbitals can be disturbed or distorted. Hard acids have a high positive oxidation state, and their valence electrons are not readily excited; soft acids and bases have little or no positive charge and easily excited valence electrons. Hard acids combine preferentially with hard bases, and soft acids with soft bases. Soft acids tend to accept electrons and form covalent bonds more readily than hard acids. For example, the hal-

ogen acids arranged in a series by increasing atomic weight (and decreasing chemical activity) show a progression from hard (HF) to soft (HI).

A brief outline of the major groups of acids is as follows:

Inorganic

Mineral acids: sulfuric, nitric, hydrochloric, phosphoric.

Hazard: All mineral acids are highly irritant and corrosive to human tissue.

Organic

Carboxylic (contain —COOH group)
    aliphatic: acetic, formic
    aromatic: benzoic, salicylic
Dicarboxylic (contain two —COOH groups)
    oxalic, phthalic, sebacic, adipic
Fatty acids (contain —COOH group)
    aliphatic: oleic, palmitic, stearic
    aromatic: phenylstearic
Amino acids: N-containing protein components
See Lewis acid; carboxylic acid; fatty acid; amino acid; specific compounds.

1,2,4-acid.   (1-amino-2-naphthol-4-sulfonic acid). $C_{10}H_5NH_2OHSO_3H$.
Properties: Pinkish-white to gray needles. Soluble in hot water; but almost insoluble in cold water.
Derivation: β-naphthol is nitrated to nitroso-β-naphthol by reaction with nitrous acid and the product treated with sodium bisulfite. Upon acidification the free sulfurous acid effects simultaneous reduction and sulfonation.
Use: Aniline dye intermediate.

1,8,2,4-acid.   See Chicago acid.

acid amide.   See amide.

acid ammonium sulfate.   See ammonium bisulfate.

acid ammonium tartrate.   See ammonium bitartrate.

acid anhydride.   An oxide of a nonmetallic element or of an organic radical which is capable of forming an acid when united with water, or which can be formed by the abstraction of water from the acid molecule, or which can unite with basic oxides to form salts.

Acid Black 2.
Use: Hair color, reagent, biological stain.

acid butyl phosphate.   See *n*-butyl acid phosphate.

acid calcium phosphate.   See calcium phosphate, monobasic.

acid dye.   An azo, triarylmethane, or anthraquinone dye with acid substituents such as nitro-, car-

boxy-, or sulfonic acid. These dyes are most frequently applied in acid soluble to wool and silk, and no doubt combine with the basic groups of the proteins of those animal fibers. Orange II (CI 15,510), black 10B, and acid alizarine blue B are examples.

acid ethylsulfate.   See ethylsulfuric acid.

acid fungal protease.   (fungal protease enzyme).
Properties: Highly off-white powder.
Use: As a replacement for pepsin; chill-proofing agent for beer; in cereal treatment; feed supplement for baby pigs; rennet extender.

acid glaucine blue.   See peacock blue.

acid, hard.   See Lewis electron theory; acid.

acidic oxide.   An oxide of a nonmetal, e.g., SO_2, CO_2, P_2O_5, SO_3, that forms an acid when combined with water.
See acid anhydride.

acidimetry.   The determination of the concentration of acid solutions or of the quantity of acid in a sample or mixture. This is usually done by titration with a solution of base of known strength (standard solution); an indicator is used to establish the end point.
See pH.

acid lining.   Silica brick lining used in steel-making furnaces.

acid magnesium citrate.   See magnesium citrate, dibasic.

acid magnesium phosphate.   See magnesium phosphate, monobasic.

acid methyl sulfate.   See methylsulfuric acid.

acid mine drainage.   (AMD).
Water from both active and inactive coal mines that has become contaminated with sulfuric acid as a result of hydrolysis of ferric sulfate, the oxidation product of pyrite. This is a factor in water and stream pollution, which can be corrected by use of appropriate ion-exchange resins.

acid number.   (acid value).
Determined by the number of milligrams of potassium hydroxide required for the neutralization of free fatty acids present in 1 g of fat or oil. Also the measure of free acids present in a substance.

acidolysis.   A chemical reaction that is comparable to hydrolysis or alcoholysis, in which water or alcohol is used in place of the acid. It involves the

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HANDBOOK OF CHEMISTRY AND PHYSICS

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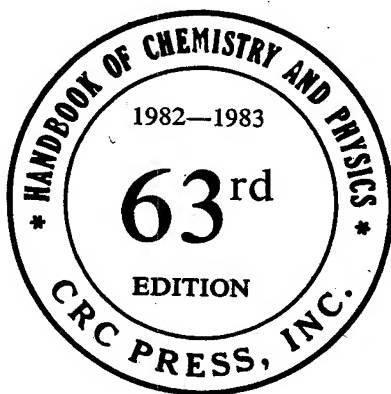
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In collaboration with a large number of professional chemists and physicists whose
assistance is acknowledged in the list of general collaborators and in connection with
the particular tables or sections involved.

CRC

EXHIBIT B

No.	Name	Synonyms and Formulae	Mol. wt.	Crystalline form, properties and index of refraction	Density or spec. gravity	Melting point, °C	Boiling point, °C	Solubility, in grams per 100 cc		
								Cold water	Hot water	Other solvents
	Lead									
1139	dithionate	$PbS_2O_6.4H_2O$	439.38	trig, 1.635, 1.653	3.22	d		115.0^{20}		
1140	thiosulfate	PbS_2O_3	319.32	wh cr	5.18	d		0.03		s a, $Na_2S_2O_3$
1141	metatitanate	$PbTiO_3$	303.09	yel, rhomb-pyr	7.52			i	i	
1142	telluride	Nat. altaite. PbTe	334.79	wh, cub	8.164^{20}_4	917				i a
1143	thiocyanate	$Pb(SCN)_2$	323.35	wh, monocl	3.82	d 190		0.05^{20}	0.2^{100}	s KCNS, HNO_3
1144	tungstate	Nat. stolzite. $PbWO_4$	455.04	tetr, 2.269, 2.182	8.23			i		i HNO_3, s KOH
1145	tungstate	Nat. raspite. $PbWO_4$	455.04	col, monocl, 2.27, 2.27, 2.30	1123			0.03		d a; i al
1146	metavanadate	$Pb(VO_3)_2$	405.07	yel powd				sl s		d HCl; s dil HNO_3
1147	Lithium	Li	6.939	silver white, soft	0.534^{20}	180.54	1342	d		
1148	acetate	$LiC_2H_3O_2.2H_2O$	102.01	wh, rhomb, α 1.40, β 1.50		70	d	300^{15}	v s	21.5 al
1149	acetylsalicylate	$LiC_9H_7O_4$	186.09	wh powd hygr, d in moist air				100		25 al
1150	metaaluminate	$LiAlO_2$ (or $Li_2Al_2O_4$)	65.92	wh, rhomb, 1.604, 1.614	2.55^{25}_4	1900–2000		i		
1151	aluminum hydride	$LiAlH_4$	37.95	wh cr powd	0.917	d 125		d		ca 30 eth
1152	amide	$LiNH_2$	22.96	col need, cub	$1.178^{17.5}$	380–400	d 750–200 subl	s	d	sl s liq NH_3, al; i eth, bz
1153	antimonide	Li_3Sb	142.57		3.2^{17}	>950		d	d	d a
1154	orthoarsenate	Li_3AsO_4	159.74	wh powd, rhomb	3.07^{18}			v sl s		s dil ac a; i pyr
1155	azide	LiN_3	48.96	col cr, hygr		d 115–298		66.41^{16}		20.26^{16} abs al; i eth
1156	benzoate	$LiC_7H_5O_2$	128.06	wh cr or powd				33^{25}	40^{100}	7.7^{25} al, 10^{75} al
1157	metaborate	$LiBO_2$	49.75	wh, tricl	$1.397^{41.7}$	845		2.57^{20}	11.83^{80}	
1158	metaborate	$LiBO_2.8H_2O$	193.87	col, trig	$1.38^{14.9}$	47				
1159	pentaborate	$Li_2B_{10}O_{16}.8H_2O$	522.10	wh	1.72	300–350 −8H_2O		36.3^{45}	194^{100}	3.9^{30} al; 22^{55} glycerine; i bz
1160	tetraborate	$Li_2B_4O_7$	169.11	wh cr		930		2.89^{20}	5.45^{100}	i org solv
1161	borohydrate	$LiBH_4$	21.78	rhomb cr	0.66	d 279		s d		s eth
1162	borohydrate	$LiBH_4$	21.78	wh, orthorhomb	0.666	275 d		v sl s		d al; 2.5 eth
1163	bromide	LiBr	86.85	wh, cub, deliq, 1.784	3.464^{25}	550	1265	145^4	254^{90}	73^{16} al; 8 MeOH; s al, eth; sl s pyrid
1164	bromide, dihydrate	$LiBr.2H_2O$	122.28	wh cr		−1H_2O; 44		246.0^{20}	v s	s al
1165	carbide	Li_2C_2	37.90	wh cr or powd	1.65^{18}			d	d	s a
1166	carbonate	Li_2CO_3	73.89	wh, monocl, 1.428, 1.567, 1.572	2.11	723	d 1310^{760}	1.54^0	0.72^{100}	i al; acet
1167	carbonate, acid	Lithium bicarbonate. $LiHCO_3$	67.96	wh				5.5^{13}		
1168	chlorate	$LiClO_3$	90.39	col, rhomb need, deliq, α 1.63, γ 1.64	1.1190^{18}_4 (18 %Soln)	127.6	300 d	500^{27}		v s al; 0.142^{25} acetone
1169	chlorate	$LiClO_3.\frac{1}{2}H_2O$ (or $\frac{1}{4}H_2O$)	99.39	wh, tetr, deliq		65(?)	−$\frac{1}{2}H_2O$, 90 d 290	v s	v s	v s al
1170	perchlorate	$LiClO_4$	106.39	wh	2.428	236	430 d	60.0^{25}	150^{89}	152^{25} al; 182^{25} MeOH; 114^{25} eth; 137^{25} acetone
1171	perchlorate, trihydrate	$LiClO_4.3H_2O$	160.44	wh, hex	1.841	95 deliq 236 (anhydr)	d 100 −2H_2O	130^{25}		72.9^{25} al; 156^{25} MeOH; 96.2^{25} acetone; 0.096^{25} eth
1172	chloride	LiCl	42.39	wh, cub, 1.662	2.068^{25}	605	1325–1360	63.7^0	130^{95}	25.10^{25} al; 42.36^{25} MeOH; 4.11^{25} acetone; $0.538^{22.9}$ NH_4OH
1173	chloride, monohydrate	$LiCl.H_2O$	60.41	wh cr, hygr	1.78	−H_2O>98		86.2^{20}	s	s HCl
1174	chloroplatinate	$Li_2PtCl_6.6H_2O$	529.78	or prism		−6H_2O, 180		v s	v s	v s al; i eth
1175	dichromate, dihydrate	$Li_2Cr_2O_7.2H_2O$	265.90	orange-red cr, deliq	2.34^{20}	187 d	110 −2H_2O	187^{20}	278^{100}	s reacts al
1177	citrate	$Li_3C_6H_5O_7.4H_2O$	281.98	col cr or powd, deliq		−4H_2O, 105		74.5^{25}	66.7^{100}	sl s al, eth
1178	fluoride	LiF	25.94	wh, cub, 1.3915	2.635^{20}	845	1676	0.27^{18}		i al; s HF
1179	fluosilicate	$Li_2SiF_6.2H_2O$	191.99	wh, monocl, 1.300, 1.296	2.33^{12}	−2H_2O, 100 d		73^{17}		s al; i eth, acet
1180	fluosulfonate	$LiSO_3F$	106.00	wh powd		360		v s	s	v s al, eth, acet; i ligorin
1181	formate, monohydrate	$H.COOLi.H_2O$	69.97	wh, rhomb	1.46	−H_2O, 94	d 230	27.85^{18}	57.05^{98}	sl s al, acet; i bz
1182	gallium hydride	$LiGaH_4$	80.69	wh cr				d	d	s eth
1183	gallium nitride	$LiGaN_2$	118.55	lt gr powd	3.35	d 800		d	d	s a, alk
1184	metagermanate	Li_2GeO_3	134.47	monocl, 1.7	3.53^{21}	1239		0.85^{25}		s a

No.	Name	Synonyms and Formulae	Mol. wt.	Crystalline form, properties and index of refraction	Density or spec. gravity	Melting point, °C	Boiling point, °C	Solubility, in grams per 100 cc		
								Cold water	Hot water	Other solvents
	Plutonium									
p151	β	Pu	239.05	monocl	17.70	stab 122±2 to 206±3				
p152	γ	Pu	239.05	orthorhomb	17.14	stab 206±3 to 319±5				
p153	δ	Pu	239.05	cub	15.92	stab 319±5 to 451±4				
p154	δ'	Pu	239.05	tetrag	16.00	stab 451±4 to 476±5				
p155	ϵ	Pu	239.05	cub	16.51	stab 476±5 to 639.5±2				
p156	bromide, tri-	$PuBr_3$	481.73	grn, orthorhomb	6.69	681		s		s dil a
p157	chloride, tri-	$PuCl_3$	348.36	emerald grn, hex	5.70	760		s		s dil a
p158	fluoride, hexa-	PuF_6	355.99	redsh-brn, orthorhomb		50.75	62.3	d		
p159	fluoride, tetra-	PuF_4	317.99	pa brn, monocl	7.0±0.2	1037				
p160	fluoride, tri-	PuF_3	299.00	purple, hex	9.32	1425(±3)		i		
p161	iodide, tri-	PuI_3	622.71	bright grn, orthorhomb	6.92	777		s		
p162	nitride	PuN	256.01	blk, cub	14.25			hydrol		s HCl, H_2SO_4
p163	oxalate	$Pu(C_2O_4)_2.6H_2O$	526.13	yel-grn				i		
p164	oxide, di-	PuO_2	274.00	yelsh-grn, cub	11.46					sl s h conc H_2SO_4, HNO_3, HF
p165	sulfate	$Pu(SO_4)_2$	434.12	light pink						s dil min a
p166	sulfate, tetrahydrate	$Pu(SO_4)_2.4H_2O$	506.18	coral pink		d 280				s dil min a
p167	**Polonium**	Po	210.05	α-Po: simple cub; β-Po: rhbr	9.4 (for β-Po)	254	962	sl s		s dil min a; v sl s dil KOH
p168	ammonium chloride	$(NH_4)_2PoCl_6$	458.85		2.76					
p169	tetrabromide	$PoBr_4$	529.67	bright red, cub		330 (in Br atm)	360[200]			s al, acet; i bz, CCl_4
p170	dichloride	$PoCl_2$	280.96	ruby red, orthorhomb	6.50	subl 190				s dil HNO_3
p171	tetrachloride	$PoCl_4$	351.86	yel, monocl or tric		300 (in Cl atm)	390	s, d		s HCl; sl s al, acet
p172	tetraiodide	PoI_4	717.67	blk cr		200 (in N atm subl)				sl s al, acet; i bz, CCl_4
p173	dioxide	PoO_2	242.05	red, tetr		d 500				
p174	selenate	$2PoO_2.SeO_3$	611.06	wh powd		>400				s dil HCl
p175	sulfate, basic	$2PoO_2.SO_3$	564.16	wh powd		>400, d 550				s dil HCl
p176	disulfate	$Po(SO_4)_2$	402.17	purp		d 550				i al; v s dil HCl
p177	monosulfide	PoS	242.11	blk		d 275				i al; sl s dil HCl
p178	**Potassium**	Kalium. K	39.0983	cub silv met	0.86[20]	63.25	760	d to KOH+d	d	d al; s a, Hg, NH_3
p179	acetate	$KC_2H_3O_2$	98.15	wh, lust powd, deliq	1.57[25]	292		253[20]	492[62]	33 al; 24.24[15] MeOH; s liq NH_3; i eth, acet
p180	acetate, acid	$K_2C_2H_3O_2.HC_2H_3O_2$	158.20	col, need or pl, hygr		148	d 200	d	d	s al, acet
p181	acetyl salicylate	$KC_9H_7O_4.2H_2O$	254.29			65				
p182	metaaluminate	$K_2Al_2O_4.3H_2O$	250.22	col cr				v s, d	v s, d	s alk; i al
p183	aluminosilicate	Nat. orthoclase. $KAlSi_3O_8$ (or $K_2O.Al_2O_3.6SiO_2$)	278.34	wh, monocl, 1.518, 1.524, 1.526	2.56	ca 1200				
p184	aluminosilicate	Nat. microcline. $KAlSi_3O_8$ (or $K_2O.Al_2O_3.6SiO_2$)	278.34	wh, tricl, 1.522, 1.526, 1.530	2.54-2.57	1140-1300				
p185	aluminosilicate	Nat. muscovite, white mica. $KAl_3Si_3O_{10}$.$(OH)_2$ (or $K_2O.3Al_2O_3.6SiO_2.2H_2O$)	398.31	col, monocl, 1.551, 1.587, 1.581	2.76-2.80	d		i		
p186	aluminum metasilicate	Nat. leucite. $KAlSi_2O_6$	218.25	col cr, 1.508	2.47	1686±5		i	i	d a
p187	aluminum orthosilicate	Nat. kaliophilite. $KAlSiO_4$	158.17	col, hex or rhomb (hex→rhomb 1540°) hex: 1.532, 1.572; rhomb: 1.528, 1.536	2.5	ca 1800 (rhomb)				
p188	aluminum sulfate	Nat. kalinite. $KAl(SO_4)_2.12H_2O$	474.39	col, cub, oct or monocl, cub: 1.454, 1.4564; hex: 1.456, 1.429	1.757[20]/[14]	92.5 −9H_2O, 64.5	−12H_2O, 200	11.4[20]	v s	i al, acet; s dil
p189	amide	Potassamide. KNH_2	55.12	col-wh, or yel-grn, hygr		335	subl 400	d	d	d al; s liq NH_3
p190	peroxylammine sulfonate	$(KSO_3)_2NO$	268.39	yel cr, expl				0.62[3], d	6.6[29], d	i al

No.	Name	Synonyms and Formulae	Mol. wt.	Crystalline form, properties and index of refraction	Density or spec. gravity	Melting point, °C	Boiling point, °C	Solubility, in grams per 100 cc		
								Cold water	Hot water	Other solvents
	Silver									
s168	nitrite	$AgNO_2$	153.88	wh, rhomb	4.453^{25}	d 140		0.155^0	1.363^{60}	s ac a, NH_4OH; i al
s169	nitroplatinite	$Ag_2[Pt(NO_2)_4]$	594.85	yel-brn monocl pr		d 100		sl s		
s170	nitroprusside	$Ag_2[FeNO(CN)_5]$	431.68	lt pink				i	s	s NH_4OH; i al, HNO_3
s171	oxalate	$Ag_2C_2O_4$	303.76	col cr	5.029^4	expl 140		0.00339^{18}		s KCN, NH_4OH, a
s172	oxide	Ag_2O	231.74	br-blk, cub	$7.143^{16.6}$	d 230		0.0013^{20}	0.0053^{80}	s a, KCN, NH_4OH, al
s173	oxide, per	Ag_2O_2 (or AgO)	247.74	gray-blk, cub	7.44	d>100		i		s H_2SO_4, HNO_3, NH_4OH
s174	palmitate	$AgC_{16}H_{31}O_2$	363.29	wh, greasy powd		209		0.0012^{20}	0.006^{25}	0.007^{15} eth; 0.006^{25} al
s175	metaphosphate	$AgPO_3$	186.84	wh, amorph	6.37	ca 482				
s176	orthophosphate	Ag_3PO_4	418.58	yel, cub	6.370^{25}	849		i		s HNO_3, NH_4OH
s177	orthophosphate, mono-H	Ag_2HPO_4	311.75	wh, trig	1.8036	d 110		$0.00065^{19.5}$		s a, KCN, NH_4OH, NH_3
s178	pyrophosphate	$Ag_4P_2O_7$	605.42	wh	$5.306^{7.5}$	585		i	i	s a, NH_4OH, KCN, ac a
s179	propionate	$AgC_3H_5O_2$	180.94	wh leaf or need	2.687^{25}_4			0.842^{20}	2.04^{80}	
s180	perrhenate	$AgReO_4$	358.07	wh cr, tetrag or rhomb	7.05	430		0.32^{25}		
s181	salicylate	$AgC_7H_5O_3$	244.99	wh to redsh-wh cr				sl s		s al
s182	selenate	Ag_2SeO_4	358.73	wh, orthorhomb cr	5.72			0.118^{20}		
s183	selenide	Ag_2Se	294.70	thin gray pl, cub	8.0	880	d	i		s NH_4OH, h HNO_3
s184	stearate	$AgC_{18}H_{35}O_2$	391.35	wh powd amorph		205		0.006^{20}		0.006^{25} al; 0.006^{25} eth
s185	sulfate	Ag_2SO_4	311.80	wh, rhomb, 1.7583, 1.7748, 1.7852	$5.45^{29.2}$	652	d 1085	0.57^0	1.41^{100}	s a, NH_4OH; i al
s186	sulfide	Nat. acanthite. Ag_2S	247.80	gray-blk, rhomb	7.326	tr 175	d		v sl s	s KCN, conc H_2SO_4, HNO_3
s187	sulfide	Nat. argentite. Ag_2S	247.80	blk, cub	7.317	825	d	8.4×10^{-15}		s KCN, a
s188	sulfite	Ag_2SO_3	295.80	wh cr		d 100		v sl s		s a, NH_4OH, KCN; i HNO_3
s189	d-tartrate	$Ag_2C_4H_4O_6$	363.81	wh, scales	3.423^{15}	d		0.2^{15}	0.203^{25}	s a, KCN, NH_4OH
s190	orthotellurate, tetra-H	$Ag_2H_4TeO_6$	443.40	straw yel, rhomb bipyr		d>200		i	i	s KCN, NH_4OH
s191	telluride	Nat. hessite. Ag_2Te	343.34	gray, cub	8.5	955		i	i	s KCN, NH_4OH
s192	tellurite	Ag_2TeO_3	391.36	yel-wh ppt		250-bl 450-pa yel		i	i	s KCN, NH_3
s193[1]	thioantimonite	Nat. pyrargyrite. Ag_3SbS_3	541.55	red, trig, 3.084 2.881 (Li)	5.76	486		i	i	s HNO_3
s193[2]	thioarsenite	Nat. proustite. Ag_3AsS_3	494.72	scarlet red, trig, 3.088, 2.792	5.49	490		i	i	s HNO_3
s194	thiocyanate	$AgSCN$	165.95	col cr		d				s NH_4OH; i a
s195	di-thionate	$Ag_2S_2O_6.2H_2O$	411.90	rhomb cr, ~1.662	3.61	d		0.0000212^{25}	0.00064^{100}	
s196	thiosulfate	$Ag_2S_2O_3$	327.87	wh cr		d		sl s		s $Na_2S_2O_3$, NH_4OH
s197	tungstate	Ag_2WO_4	463.59	pa yel cr				0.05^{15}		s KCN, NH_4OH, HNO_3
	Silver complex									
s198	diamminesilver perrhenate	$[Ag(NH_3)_2]ReO_4$	392.13	col monocl cr	3.901					1.618 conc NH_4OH
s199	**Sodium**	Na	22.9898	silv, met cub, 4.22	0.97	97.81 ± 0.03	882.9	d to NaOH + H_2		d al; i eth; bz
s200	acetate	$NaC_2H_3O_2$	82.03	wh gr powd, monocl, 1.464	1.528	324		119^0	170.15^{100}	sl s al
s201	acetate trihydrate	$NaC_2H_3O_2.3H_2O$	136.08	col, monocl pr, effl, β 1.464	1.45	58	123, −3H_2O, 120	76.2^0	138.8^{50}	2.1^{18} al; s eth
s202	alumina trisilicate	Nat. albite. $NaAlSi_3O_8$ (or $Na_2O.Al_2O_3.6SiO_2$)	262.22	col, tricl, 1.525, 1.529, 1.536	2.61	1100			sl d	s HCl; d dil al
s203	metaaluminate	$NaAlO_2$	81.97	wh amorph powd, hygr, 1.566, 1.595, 1.580		1800		s	v s	i al
s204	aluminum chloride	$NaCl.AlCl_3$	191.78	wh-yelsh cr powd, hygr		185		s	s	
s205	aluminum metasilicate	Nat. jadeite. $Na_2O.Al_2O_3.4SiO_2$	404.28	col, monocl	3.3	1000–1060		i	i	d HCl